THE MEASUREMENT OF LEAD AND IRON CONCENTRATION IN THE SNOW OF NORTHEAST COLUMBUS, OHIO

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June 9, 1970

INTRODUCTION

Pollution of the land, air, and water of this planet is a growing problem which must be solved. As geologists, who study the earth as a profession, it should be our duty to help solve the problem by discovering what the pollutants are, where they are being concentrated, and if possible, to determine their source. The purpose of this paper is to report the results of an experiment conducted to determine the amount of iron and lead pollution in the snow of northeast Columbus, Ohio.

GENERAL DESCRIPTION

The area studied is roughly rectangular in shape, and encloses approximately thirty square miles. It is bounded by State Route 161 to the north, Hamilton Road to the east, 5th Avenue to the south, and by Stelzer Road and Sunbury Road to the west. The area is largely residential; the two important exceptions to this being Port Columbus International Airport at the extreme south end of the area, and a highway construction project at the north end, which at the time of this writing is still continuing.

Snow was collected at twenty-seven points numbered 1-28. (Sample 11, located at the intersection of Hamilton Road and 5th Avenue was not collected.) These points were then plotted on a map of the area. Samples 1-10 were collected on January 15, and samples 12-28 on January 18, 1970. As is shown on the Local Climatological Data Chart, published by the U. S. Department of Commerce, there were six inches of relatively fresh snow on the ground on January 15. There was no snowfall between January 15, and January 18, and by January 18, due to a warming trend,

only two inches of snow remained. Because it was on the ground longer, we might expect samples 12-28 to contain higher concentrations of lead and iron than samples 1-10, if any of the pollutants had settled out of the air between January 15 and 18.

SAMPLING PROCEDURE AND ANALYSIS

Each snow sample was collected in a plastic bottle previously washed with distilled water. A plexiglass plate was pushed under the snow. An aluminum pipe was pushed down into the snow to the plate. The pipe was then lifted out, and the snow it contained was tamped into the bottles by a wooden dowel. In some places, the snow was too shallow for this procedure to be followed, and it had to be scraped into the bottles with the plate. The analysis of the samples was accomplished by the following procedure. When the snow was melted, it was discovered that each sample contained a small amount of solid material. It was therefore necessary to make sure that all iron and lead in the samples was in solution before they were analyzed. Each sample was treated with 1.5 c.c. of concentrated hydrochloric acid and allowed to stand for one hour in their respective bottles, which were capped. Then most of the liquid was poured off and its volume measured, leaving approximately 4 to 10 c.c. of liquid with the solid material. The remaining liquid was poured off and its volume measured. The sample bottles were then washed free of solids with a small amount of distilled water, and this water and the solids were added to the small liquid portion of the sample. To this now diluted portion approximately 10c.c. of concentrated hydrochloric acid was added and the solution boiled slowly to a volume of 1 to 3 c.c. This solution was then diluted with distilled water back to the original volume of the small liquid portion of the sample. This treatment was believed sufficient to

dissolve all the iron and lead in the solid portion of the sample. Thus each sample was analyzed in two parts; the smaller liquid portion (concentrated), and the large unconcentrated solution of the melted snow and acid. The results were recombined by the method described below.

The equipment used for the analysis was a Perkin-Elmer Model 303 Atomic Absorption Spectrophotometer owned by the Department of Chemical Engineering of The Ohio State University. In using this machine, the solution being analyzed is drawn into the machine and ionized in a flame using acetylene and air. A beam of light of appropriate wavelength for the element being measured is passed through the flame. The amount of light absorbed is measured. A standard of known concentration is prepared, and by comparing the per cent of absorption of the standard with that of the sample, the concentration of the element can be determined. The following is a sample calculation showing how the concentration of iron in each part of snow sample number one was determined, and how each part was recombined to determine the concentration for the whole sample.

1. Volume: small portion: 6.5 c.c. large portion: 30.0 c.c.

2. Standards used:
   a. 2.5 p.p.m. Fe= absorption=8.55, % absorption (from table) = .0388.
      % abs. 1 p.p.m.= .0388/2.5=.0155
   b. 5 p.p.m. Fe= absorption=16.6, % absorption (from table)=.0788
      % abs. 1 p.p.m.= .0788/5= .0157

3. absorption of large portion= 2.3; % abs. (from table) = .0101 p.p.m. Fe= .0101/.0155= 0.6

   absorption of concentrated portion= 17.7; % abs.(from table)= .0846 p.p.m. Fe= .0846/.0157= 5.4

4. # c.c. x p.p.m. = total micrograms in each sample
   a. concentrated portion: 5.4 p.p.m. x 6.5 c.c. = 35.0
   b. large portion: 0.6 p.p.m. x 30.0 c.c.= 18.0
5. total micrograms Fe in sample = 35+18=53
6. total c.c. in sample = 30.0+6.5 = 36.5
7. total concentration Fe in sample = 53/36.5 = 1.5 p.p.m

Concentrations of iron and lead in the distilled water and acid used were measured and found to be insignificant.

RESULTS

In the table the concentrations of iron and lead are shown along with the average concentration of each element for samples 1-10, and the average concentration for samples 12-28. The concentration of iron and lead in each sample was plotted at its place of collection on the appropriate map. Referring to the maps, it can be seen that high concentrations of iron exist at Port Columbus on the south, Stygler Road in the center, and Morse Road at the northwest corner of the area. High lead concentrations are located at Fifth Avenue on the south, Hamilton Road at U. S. Route 62 on the northeast, and Morse Road at Sunbury Road on the northwest part of the area. The average concentration of iron for samples 1-10 is 2.9 p.p.m. For samples 12-28 it is 3.7 p.p.m., showing that an increase of 27% in the concentration of iron in the snow occurred between January 15 and January 18. The average concentration of lead in samples 1-10 was .42 p.p.m. while in samples 12-28, it was .40 p.p.m. This is only a 5% decrease in the concentration of lead over the same period, and is probably insignificant. The resultant wind direction for the period of January 1-January18 was azimuth 240°.

The resultant direction for the entire month was the same.

INTERPRETATION OF RESULTS

In interpreting the results, it was first necessary to plot frequency distributions of concentration (included with the results) to determine whether the distribution of iron and lead over the area was uniform. In examining the diagram of lead distribution, it is seen that the two groups of samples basically have the same distribution, slight differences occurring because of different numbers of samples in the groups. From the diagram, then, it appears that lead is evenly distributed over the sampling area, and due to the insignificant change in average concentration, is also evenly distributed in time. Iron presents a more complicated distribution. The frequency distribution diagram for iron shows that the distribution of concentration of each group of samples is exactly the same up to 3 p.p.m. but then diverges. In the distribution of samples 12-28, seven samples contained between 4 and 8 p.p.m., while in samples 1-10, no sample contained an amount in this range. In examining the map, it is seen that the values in this range are clustered in particular areas- one being Port Columbus, another at sample 16, and another at sample 27. It appears that iron is either unevenly distributed over the sampling area, or in time. The 27% increase in average concentration from January 15- 18 suggests uneven distribution in time.

In determining the source of the iron in the area, it was assumed that a significant amount comes from dry fallout onto the snow. Usually iron accumulates in the air as the result of industrial smelting, grinding, welding, or burning of coal. Lower grades of coal sometimes contain large amounts

of pyrite, from which flyash is liberated. If a line is drawn through samples 23 and 16 parallel to the resultant wind direction, the line passes directly over the Timken Roller Bearing Company plant at 5th and Cleveland Avenues. This or other factories in that immediate area could be the source of the high concentrations of iron at sample sites 16 and 23. The high concentration at sample 27 is not easily explained. A line parallel to resultant wind direction drawn through this sample passes approximately one mile north of the O.S.U. power plant, but does not cross any greatly industrialized area. The power plant may be a contributor to this concentration, but other sources are probably sharing responsibility for it. At Port Columbus, the concentration lines on the map do not follow the wind pattern, but seen to follow the path of the aircraft into and out of the airport. It seems that the iron in this area ~~must~~ mail come from aircraft exaust.

As a pollutant, iron presents little danger to public health. Outside of staining pots and pans, it does little harm. Therefore, even though iron accumulates with or falls out on snow, it is not considered to be of grave concern.

As mentioned above, lead was found to be fairly evenly distributed over the area. It is very probably almost exclusively derived from automobile exaust. The lead in the area therefore is probably concentrated along the highways. For this reason lead contours were not drawn on the map. There is evidence which supports the statement that lead concentrates along highways. Most of the samples containing high concentrations of lead are located at intersections or parking lots. We would expect this because in lots and at traffic lights, there would be more exaust due to stopping and starting. Samples 5 and 27,

wher exceptionally high concentrations of lead occur, deserve special mention. At sample 27, the intersection is located at the base of a steep hill. The high concentration here could be due to added exhaust from engines starting up the hill. Near sample 5, U.S. Rt 62 is approximately parallel to the resultant wind direction. It is possible that while the snow fell, the wind blew lead in the air along the highway toward sample 5, where it accumulated. This sample is also located closer to the road than the others, which could also account for a higher lead concentration in the sample. There does not seem to be a significant drop in concentration in samples collected on the windward sides of the roads, even though the snow did not fall during a calm.

The very slight change in average concentration from January 15 - 18 probably means that lead was removed from the air by the falling snow, but did not continue to accumulate afterwards by fallout. As the snow melts, lead will begin to infiltrate the streams and groundwater of the area. The safe concentration of lead in drinking water established by the State of Ohio Water Pollution Control Board is .03 p.p.m. The average concentration of lead in the snow samples collected was approximately .42 p.p.m. or fourteen times the amount considered safe. This means that large amounts of lead are being added to the ground water and streams of the area. If this is allowed to continue, lead concentrations in wells used for drinking water in the area may reach a dangerous level. It is already past the danger point in the snow. It is well that no wildlife in the area depends on snow for drinking water, and the eating of snow by children should be discouraged.

CONCLUSIONS

The most obvious conclusion that can be made from this experiment is that snow is dirty. It should not be used for human consumption. The second conclusion is that this experiment is both practical and successful for determining concentrations of iron and lead in snow on the ground, and could probably be used for larger areas and other elements with equally good results.

ACKNOWLEDGEMENTS

Grateful acknowledgement is given to Wayne Hamilton, Institute of Polar Studies, The Ohio State University, who served as advisor for the project, and to Paul Smith, Department of Chemical Engineering, The Ohio State University, whose technical assistance contributed greatly to the completion of this project.

LOCAL CLIMATOLOGICAL DATA

U.S. DEPARTMENT OF COMMERCE
MAURICE H. STANS, Secretary
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
ENVIRONMENTAL DATA SERVICE

COLUMBUS, OHIO
PORT COLUMBUS AIRPORT
JANUARY 1970

Latitude 40° 00′ N Longitude 82° 53′ W Elevation (ground) 812 ft. Standard time used: EASTERN

Date	Temperature (°F) Maximum	Minimum	Average	Departure from normal	Average dew point	Degree days (Base 65°) Heating	Cooling	Weather types shown by code 1-9 on dates of occurrence (1 Fog, 2 Heavy Fog, 3 Thunderstorm, 4 Sleet, 5 Hail, 6 Glaze, 7 Duststorm, 8 Smoke, Haze, Blowing Snow, 9)	Snow, Sleet, or Ice on ground at 07AM (In.)	Precipitation Water equivalent (In.)	Snow, sleet (In.)	Avg. station pressure (In.) Elev. 833 feet m.s.l.	Wind Resultant direction	Resultant speed (m.p.h.)	Average speed (m.p.h.)	Fastest mile Speed (m.p.h.)	Fastest mile Direction	Sunshine Hours and tenths	Sunshine Percent of possible	Sky cover (Tenths) Sunrise to sunset	Sky cover (Tenths) Midnight to midnight	Date
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	31	26	29	-1	24	36	0	8	1	.14	2.2	29.13	21	9.7	8.6	16	W	0.0	0	10	10	1
2	30	24	27	-3	23	38	0	1 8	2	.06	1.5	29.14	20	8.3	9.6	16	SW	0.0	0	10	10	2
3	27	15	21	-9	13	44	0	8	3	.04	.7	29.15	27	10.8	11.4	17	W	1.5	16	9	9	3
4	22	12	17	-13	12	48	0	8	3	.01	.3	29.26	22	7.0	9.1	15	SW	1.4	15	9	8	4
5	36	7	22	-8	17	43	0	8	3	T	.2	29.34	22	2.7	7.1	16	SW	3.3	35	6	5	5
6	27	12	20	-10	14	45	0	1 8	3	.03	.7	29.22	34	9.8	10.2	15	NW	0.5	5	10	10	6
7	12	-1	6	-24	-3	59	0	8	3	.01	.2	29.16	25	11.0	12.4	22	W	5.7	60	7	7	7
8	-1	-6*	-4	-34	-13	69	0	89	3	T	T	29.22	24	18.6	18.7	28	W	3.0	42	9	6	8
9	6	-3	2	-28	-8	63	0	89	3	.04	.6	29.30	24	16.0	16.3	23	SW	3.9	40	9	9	9
10	13	4	9	-21	-1	56	0	8	4	.03	.7	29.41	20	8.6	9.9	13	SW	8.7	91	1	4	10
11	24	6	15	-15	11	50	0	1 6	3	.18	2.6	29.11	13	7.2	7.5	11	S	0.0	0	10	10	11
12	28	15	22	-8	18	43	0	1 6 8	5	T	T	29.12	29	9.2	9.9	17	NW	0.0	0	10	7	12
13	26	3	15	-15	8	50	0	1 8	5	0	0	29.35	18	5.6	6.8	10	SE	5.6	58	4	4	13
14	25	14	20	-10	13	45	0	8	5	.11	2.7	29.34	08	2.8	4.2	7	E	0.0	0	10	9	14
15	34	13	24	-6	13	41	0	8	6	T	T	29.33	12	5.4	6.2	11	E	6.8	70	7	5	15
16	42	13	28	-2	21	37	0	1 8	5	T	0	29.28	18	4.7	4.9	12	S	6.4	66	8	6	16
17	42	34	38	8	31	27	0	1 8	3	T	0	29.07	20	3.6	7.1	9	NW	0.0	0	10	10	17
18	35	11	23	-7	15	42	0	1 4	2	.03	.1	29.10	34	12.8	12.9	17	N	4.8	49	9	7	18
19	19	9	14	-16	4	51	0		1	.02	.5	29.23	31	5.5	6.9	14	W	5.3	54	6	7	19
20	12	-5	4	-26	-3	61	0	89	2	.05	1.4	29.12	28	9.6	11.7	25	W	2.1	21	10	7	20
21	11	-5	3	-27	-7	62	0		3	0	0	29.47	28	10.9	11.1	23	W	9.4	96	1	2	21
22	16	-5	6	-24	-6	59	0	8	3	0	0	29.37	19	6.8	9.4	13	S	8.2	83	7	6	22
23	24	12	18	-12	11	47	0	8	3	.06	1.7	29.07	25	2.6	8.3	16	SW	0.0	0	10	10	23
24	29	-4	13	-17	8	52	0	8	3	T	T	29.17	16	6.0	7.8	20	S	1.8	18	9	7	24
25	45	26	36	6	31	29	0	1	3	.02	0	28.79	18	9.6	11.7	23	SW	0.0	0	10	10	25
26	41	32	37	7	27	28	0	1 8	T	.04	.4	28.99	27	9.0	10.4	25	W	0.0	0	10	10	26
27	35	29	32	2	26	33	0	1 8	1	.05	.7	29.17	23	7.2	10.2	25	W	0.0	0	10	10	27
28	60*	29	45	15	34	20	0		0	0	0	28.96	16	15.1	17.0	30	SW	0.0	0	10	10	28
29	58	30	44	14	35	21	0	1 8	0	.66	T	28.92	26	11.5	13.2	22	NW	0.0	0	10	10	29
30	30	22	26	-4	16	39	0	8	T	.02	1.2	29.29	28	9.4	11.4	26	NW	5.4	54	7	9	30
31	46	22	34	4	20	31	0		T	0	0	29.26	21	11.9	12.7	27	SW	9.2	90	1	4	31
	Sum 885	Sum 391				Total 1369	Total 0			Total 1.60	Total 18.4	For the month: 29.19	24	5.1	10.1	30	SW	Total 93.0	% for	Sum 249	Sum 238	
	Avg. 28.5	Avg. 12.6	Avg. 20.6	Dep. -9.3	Avg. 13	Dep. 281	Dep.	Number of days		Dep. -1.56						Date: 28		Possible 300.8	month 31	Avg. 8.0	Avg. 7.7	
						Season to date		Precipitation ≥ .01 inch 19														
	Number of days					Total	Total	Snow, sleet ≥ 1.0 inch 7		Greatest in 24 hours and dates						Greatest depth on ground of snow, sleet or ice and date						
	Maximum Temp.		Minimum Temp.			3775	0	Thunderstorms 0		Precipitation		Snow, Sleet										
	≥ 32°	≤ 90° ‡	≤ 32°	≤ 0°		Dep.	Dep.	Heavy fog X 0		.66	29	2.7	14			7	14					
	20	0	30	7		497																

HOURLY PRECIPITATION (Water equivalent in inches)

Date	A.M. Hour ending at 1	2	3	4	5	6	7	8	9	10	11	12	P.M. Hour ending at 1	2	3	4	5	6	7	8	9	10	11	12	Date
1		T	T			.02	.03	.02	.02	.01	.01	.01	.01	.01	T	T	T	T	T	T	T	T	T	T	1
2	T	T				T	T	T	T	.01	.01	.01	T	.01	.01	T	T	T	T	T	.01	T	T	T	2
3	.01	.01	.01	.01	T	T	T	T	T	T	T	T		T	T			T	T	T	T	T	T	T	3
4	T	T	T	T	T	T	T	T	.01	T	T	T	T	T	T	T	T								4
5																						T	T		5
6	.01	T	.01	T	T	T	T	T										T	T	T	T	T	.01		6
7	T	T	T	T	T	T	T	T	T	.01	T						T	T				T	T		7
8	T															T	T	T	T			T	T		8
9	T	.01	T	T	T	.01	T	T	T		T	T	T	T	T	T	.01	T	T	T	.01	T	T		9
10	T	.01	T	.01	.01	T	T	T	T																10
11									T	.02	.02	.02	.01	.02	.01	.01	.01	.01	.01	.02	.01	T	T	.01	11
12	T	T	T	T	T	T	T	T	T	T	T	T	T	T											12
13																									13
14				T	T	.01	.01	.03	.02	.01	.01	.01	.01	T	T	T	T	T	T	T					14
15				T	T																				15
16																								T	16
17	T						T	T												T	T	T	T	T	17
18	.02	T	T	.01	T	T	T																		18
19								T	.01	.01	T										T	T	T	T	19
20	T	T					T	T	T	.01	.02	.01	T	.01	T	T	T	T							20
21																									21
22																									22
23			T	.01	.01	.01	T	T	T	.01	.01	T	T	T	T	T	T	T	T	T	T	.01	T	T	23
24														T	T			T							24
25														T	T	T	.01	T	T						25
26						T	.01	T	.01	.01	.01	T	T	T	T	T	T								26
27	T					.02	.02	.01	T	T	T	T	T												27
28																									28
29		T	.38	.15	.08	.05	T	T	T			T			T	T	T	T	T	T	T	T	T		29
30			T	T	T	T	T	.02	T	T						T	T	T	T	T	T	T	T		30
31																									31

* Extreme temperatures for the month. May be the last of more than one occurrence.
– Below zero temperature or negative departure from normal.
‡ ≥ 70° at Alaskan stations.
\+ Also on an earlier date, or dates.
X Heavy fog restricts visibility to ¼ mile or less.
T In the Hourly Precipitation table and in columns 9, 10, and 11 indicates an amount too small to measure.

The season for degree days begins with July for heating and with January for cooling.
Data in columns 6, 12, 13, 14, and 15 are based on 8 observations per day at 3-hour intervals.
Wind directions are those from which the wind blows. Resultant wind is the vector sum of wind directions and speeds divided by the number of observations. Figures for directions are tens of degrees from true North; i.e., 09 = East, 18 = South, 27 = West, 36 = North, and 00 = Calm. When directions are in tens of degrees in Col. 17, entries in Col. 16 are fastest observed 1-minute speeds. If the / appears in Col. 17, speeds are gusts.

Any errors detected will be corrected and changes in summary data will be annotated in the annual summary.

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I certify that this is an official publication of the Environmental Science Services Administration, and is compiled from records on file at the National Weather Records Center, Asheville, North Carolina 28801.

William N. Haggard

Director, National Weather Records Center

SUMMARY BY HOURS

Hour (Local time)	AVERAGES Sky cover (Tenths)	Station pressure (In.)	Dry bulb (°F)	Wet bulb (°F)	Rel. hum. %	Dew point (°F)	Wind speed (m.p.h.)	Resultant wind Direction	Resultant wind Speed (m.p.h.)
01	7	29.19	20	18	73	12	9.0	25	4.5
04	7	29.19	18	17	74	11	8.5	24	3.5
07	7	29.19	17	16	75	11	9.3	23	2.8
10	8	29.21	19	17	76	12	9.8	23	4.7
13	8	29.18	23	21	69	14	12.0	23	7.3
16	9	29.17	25	23	67	16	12.8	24	8.4
19	8	29.19	24	21	70	15	10.5	24	5.8
22	7	29.19	21	19	71	13	9.2	24	4.0

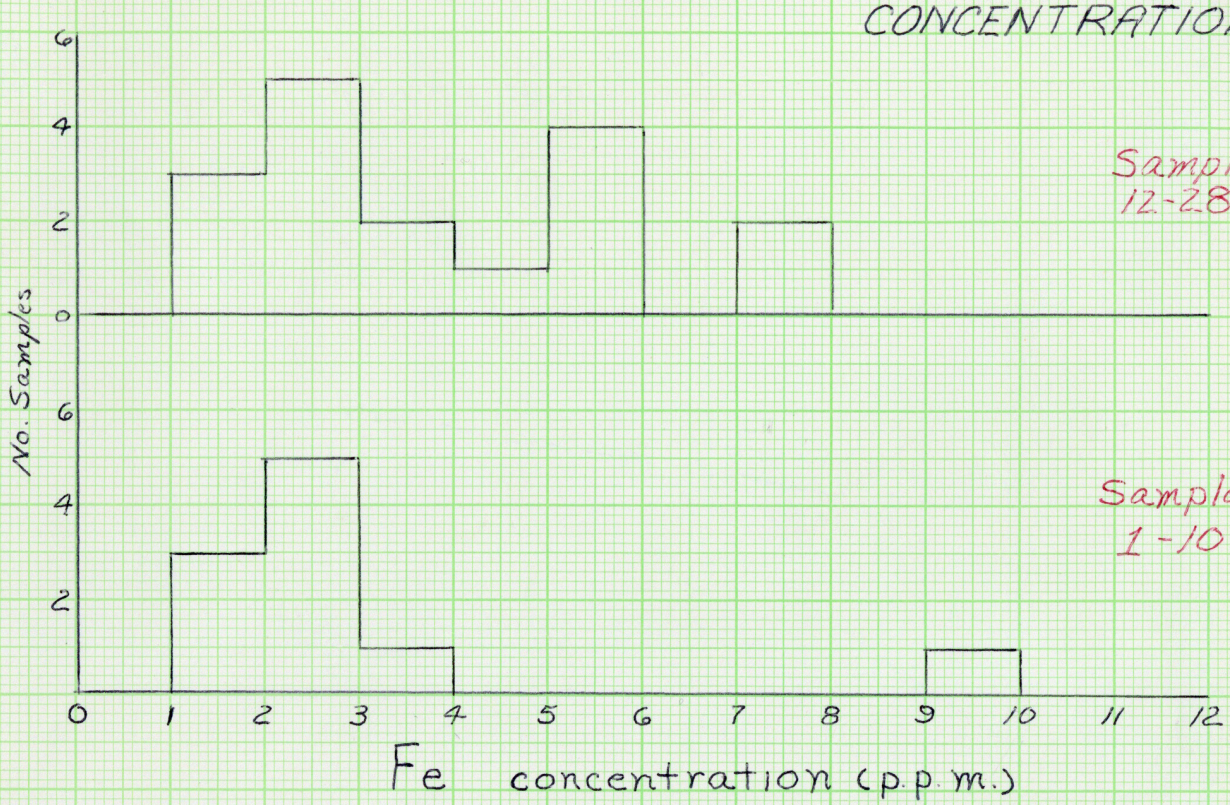
RESULTS

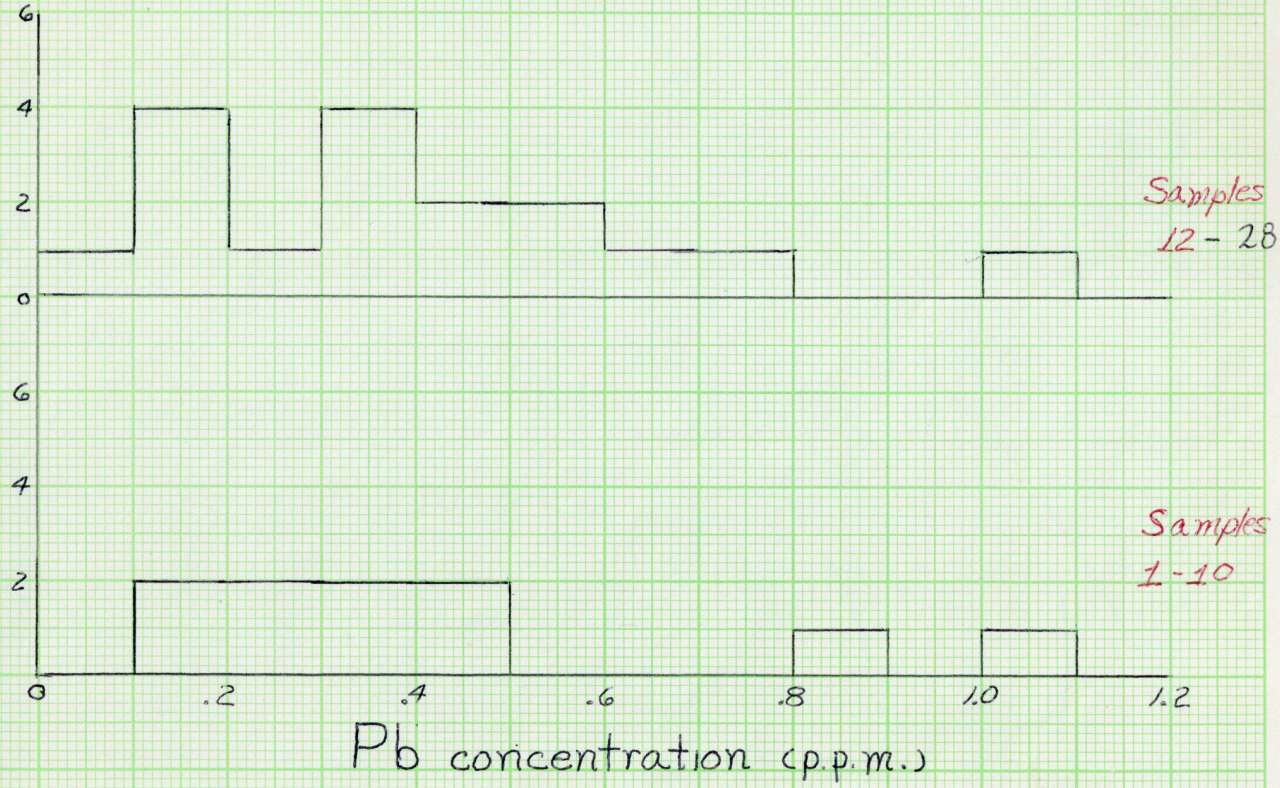
Sample #	p.p.m. Fe	p.p.m. Pb	Dist. from Rd. (ft.)	Remarks
1.	1.5	.44	80	gas station
2.	1.5	.11	30	
3.	1.8	.26	30	
4.	3.2	.15	30	
5.	2.3	1.09	10	downwind USRT 62
6.	2.3	.40	50	
7.	2.6	.35	50	
8.	2.2	.35	50	
9.	2.8	.25	50	
10.	9.5	.80	25	aircraft approach
12.	3.2	.15	30	construction
13.	2.1	.11	50	
14.	2.5	.15	25	
15.	1.3	.23	100	cornfield
16.	7.6	.41	75	schoolyard
17.	1.4	.42	50	
18.	5.2	.31	15	dead-end Rd.
19.	3.6	.58	60	railroad yard
20.	5.2	.72	50	parking lot
21.	5.3	.37	30	
22.	2.0	.59	50	
23.	4.6	.69	75	woods
24.	1.4	.05	50	
25.	2.5	.38	45?	woods
26.	5.0	.15	50	
27.	7.2	1.08	30	
28.	2.8	.36	50	

Average concentration Fe samples 1-10 = 2.9 p.p.m.
" " " 12-28 = 3.7 p.p.m.

" " Pb 1- 10 = .42 p.p.m.
" " " 12-28 = .40 p.p.m.

FREQUENCY DISTRIBUTION OF CONCENTRATION





MAP OF N.E. COLUMBUS, O.

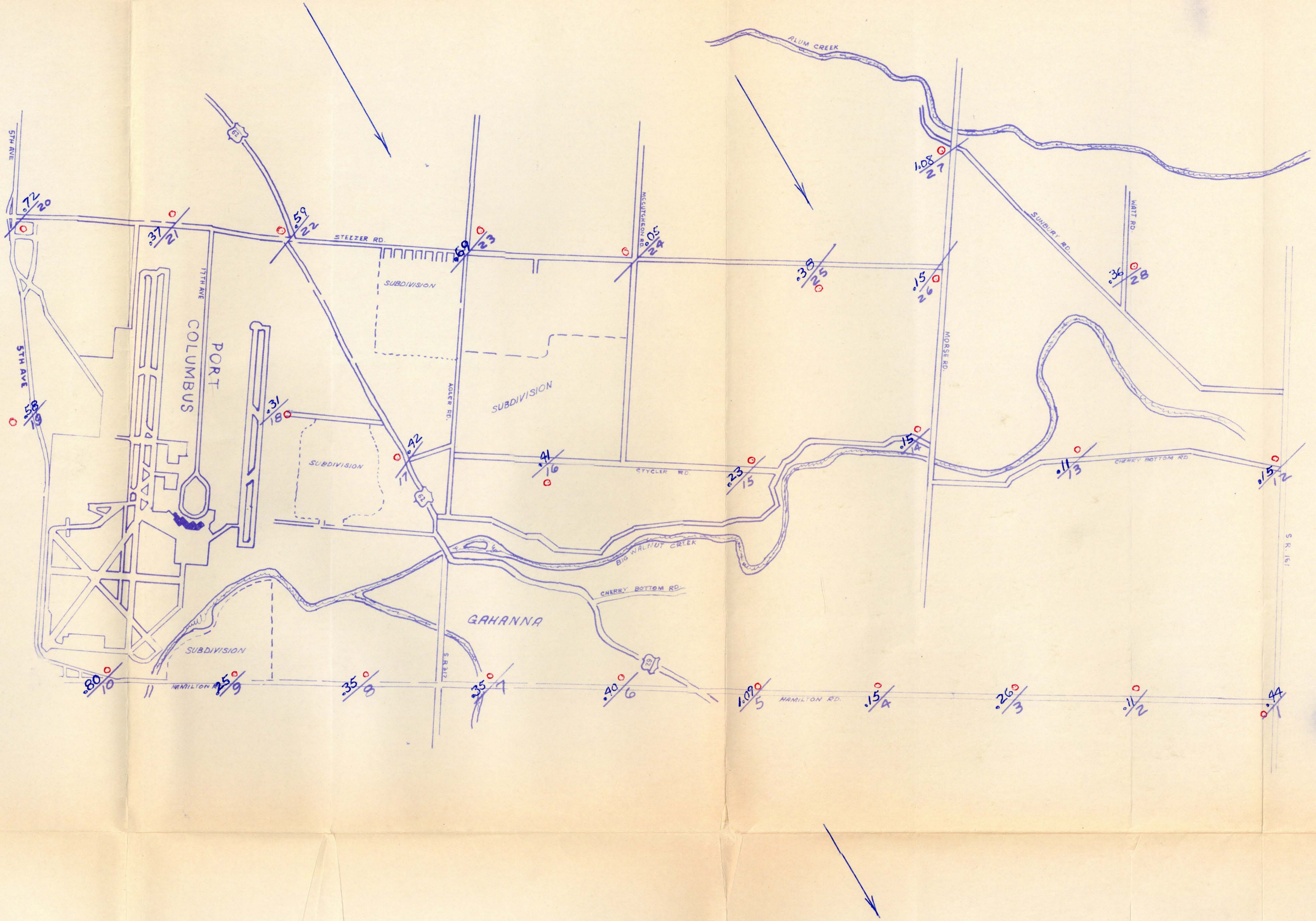
SNOW COLLECTION PTS. &
METAL CONCENTRATIONS IN P.P.M.

METAL: LEAD

N

SCALE: 2" = 1 MI.

Resultant Wind Dir.



MAP OF N.E. COLUMBUS, O.

SNOW COLLECTION PTS. & METAL CONCENTRATIONS IN P.P.M.

METAL: IRON

N

SCALE: 2" = 1 MI.

Resultant Wind Direction →